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409

NOAA Technical Report NMFS Circular 409

Marine Flora and Fauna of the Northeastern United States. Copepoda: Cyclopoids Parasitic on Fishes

Ju-Shey Ho

February 1978

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Ju-Shey Ho

February 1978

U. S. Depository Copy

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary
National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator
National Marine Fisheries Service

FOREWORD

This issue of the "Circulars" is part of subseries entitled "Marine Flora and Fauna of the Northeastern United States." This subseries will consist of original, illustrated, modern manuals on the identification, classification, and general biology of the estuarine and coastal marine plants and animals of the Northeastern United States. Manuals will be published at irregular intervals on as many taxa of the region as there are specialists available to collaborate in their preparation.

The manuals are an outgrowth of the widely used "Keys to Marine Invertebrates of the Woods Hole Region," edited by R. I. Smith, published in 1964, and produced under the auspieces of the Systematics-Ecology Program, Marine Biological Laboratory, Woods Hole, Mass. Instead of revising the "Woods Hole Keys," the staff of the Systematics-Ecology Program decided to expand the geographic coverage and bathymetric range and produce the keys in an entirely new set of expanded publications.

The "Marine Flora and Fauna of the Northeastern United States" is being prepared in collaboration with systematic specialists in the United States and abroad. Each manual will be based primarily on recent and ongoing revisionary systematic research and a fresh examination of the plants and animals. Each major taxon, treated in a separate manual, will include an introduction, illustrated glossary, uniform originally illustrated keys, annotated check list with information when available on distribution, habitat, life history, and related biology, references to the major literature of the group, and a systematic index.

These manuals are intended for use by biology students, biologists, biological oceanographers, informed laymen, and others wishing to identify coastal organisms for this region. In many instances the manuals will serve as a guide to additional information about the species or the group.

Geographic coverage of the "Marine Flora and Fauna of the Northeastern United States" is planned to include organisms from the headwaters of estuaries seaward to approximately the 200-m depth on the continental shelf from Maine to Virginia, but may vary somewhat with each major taxon and the interests of collaborators. Whenever possible representative specimens dealt with in the manuals will be deposited in the reference collections of major museums in the region.

After a sufficient number of manuals of related taxonomic groups have been published, the manuals will be revised, grouped, and issued as special volumes. These volumes will thus consist of compilations of individual manuals within phyla such as the Cnidaria, Arthropoda, and Mollusca, or of groups of phyla.

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Marine Flora and Fauna of the Northeastern United States. Copepoda: Cyclopoids Parasitic on Fishes

JU-SHEY HO[1]

ABSTRACT

This manual includes an introduction on the general biology, an illustrated key, an annotated systematic list, a selected bibliography, and an index to the 19 species of cyclopoid copepods parasitic on marine fishes of the northeastern United States.

INTRODUCTION

The "Order Cyclopidea" as defined by Yamaguti (1963) consists of four families of copepods parasitic on both freshwater and marine fishes. They are Bomolichidae, Ergasilidae, Grandiunguidae, and Tuccidae. However, according to Sproston et al. (1950), Ho (1967b, 1970, 1971a), Izawa (1973), and Cressey (1975), the Order should include six more families: Lernaeidae, Telsidae, Chondracanthidae, Pharodidae, Philichthyidae, and Shiinoidae; and the family Bomolichidae should be separated into the Bomolochidae and Taeniacanthidae. The family Grandiunguidae was created by Yamaguti (1963) to accommodate a single species of copepod, *Grandiungus promicrops* Pearse 1952. I have checked the type-specimen of this species deposited in the National Museum of Natural History in Washington, D.C., and have discovered that it is merely a chalimus larva of a lernaeocerid copepod detached from its frontal filament. Therefore, the family Grandiunguidae together with its monotypic genus and species, *Grandiungus promicrops*, should be discarded. Consequently, the "Order Cyclopidea" as it now stands consists of ten families, namely, Bomolochidae, Chondracanthidae, Ergasilidae, Lernaeidae, Pharodidae, Philichthyidae, Shiinoidae, Taeniacanthidae, Telsidae, and Tuccidae. The lernaeids are exclusively parasitic on freshwater fishes and the ergasilids are predominently parasites of freshwater fishes, except a few species that are found on fishes of brackish or coastal waters. The members of the other eight families are strictly marine parasites.

Cyclopoid copepods on fishes are found on the body surface or in the oral cavity, gill cavity, nasal cavity, and cephalic canal. They attach to the host by hooking their modified, prehensile second antennae (Ergasilidae, Chondracanthidae, Pharodidae, Tuccidae), maxillae (Telsidae), or maxillipeds (Bomolochidae, Shiinoidae, Taeniacanthidae); by burrowing their anchorlike modified cephalothorax (Lernaeidae); or by boring into and lying free inside the cephalic canal of the host's gill operculum and head (Philichthyidae).

Our knowledge of the biology of this group of parasites is still scanty. A complete life cycle is known of only some freshwater species. Some sporadic reports on the larval stages are available for a few marine species. However, based on the existing information, it seems that the parasitic cyclopoids do not require an intermediate host. The nauplius hatched from the egg develops into the copepodid larva, which is the infective stage and searches for the new host. Usually, there are five copepodid stages and mating takes place right after the female finishes its last molt in the larval stage. The male dies after mating, but occasionally it is found holding to the genital segment of the ovigerous female (Bomolochidae, Shiinoidae, Taeniacanthidae, Telsidae) or lying in the host's cephalic canal with the mature female (Philichthyidae). However, in the family Chondracanthidae, the male is characteristically a symbiont of the female; it is a dwarf (Fig. 1) and holds on to one of the two vermiform processes on the female trunk near the genital somite. Therefore, adult cyclopoids found attached to fishes are all female. The mature females of the families Chondracanthidae, Lernaeidae, Pharodidae, Philichthyidae, Shiinoidae, and Tuccidae are highly transformed and do not appear as a typical cyclopoid (Fig. 2). In these modified copepods an extensive but gradual modification of the body occurs in the process of maturation after the last molt in the copepodid stage.

While all the cephalic and oral appendages are retained with certain degree of modification in the adult female, the thoracic appendages of the parasitic cyclopoids exhibit a wide spectrum of variation. While the maxillipeds are lacking in some families (Ergasilidae, Philichthyidae, Shiinoidae), the remaining thoracic appendages vary from the typical unmodified cyclopoid thoracopods (Ergasilidae, Lernaeidae) through the partially (Bomolochidae, Taeniacanthidae, Telsidae, Tuccidae) or completely (Chondracanthidae, Pharodidae, Philichthyidae) modified legs to the absence of the legs entirely (Chondracanthidae, Philichthyidae).

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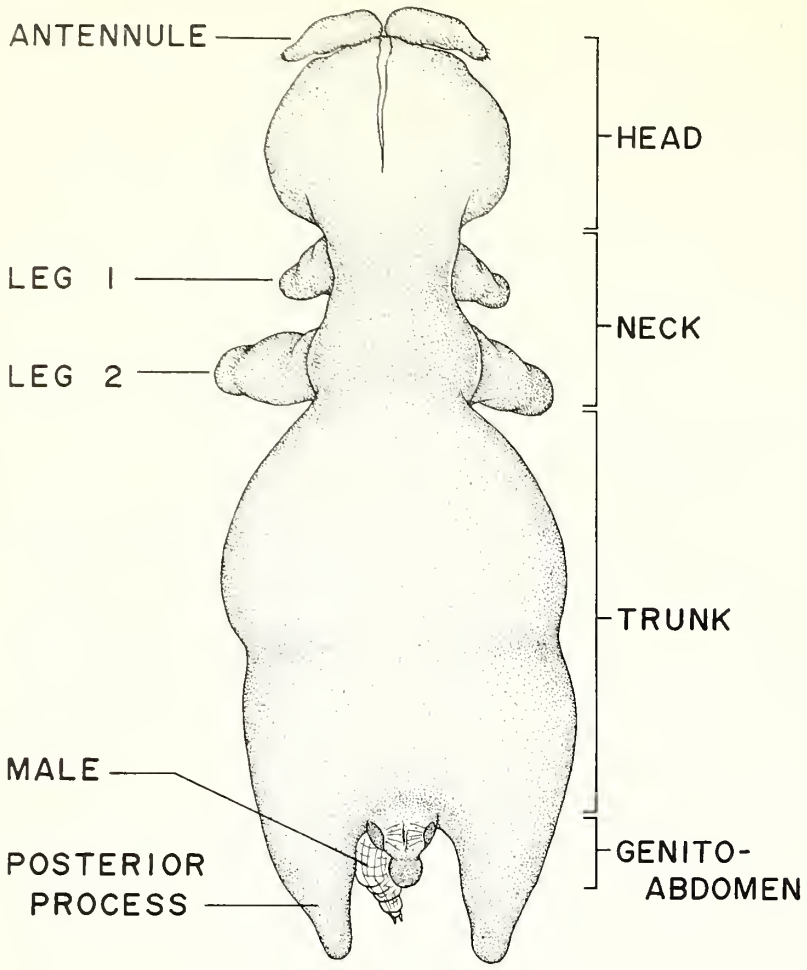


Figure 1.—*Acanthochondria cornuta*; dorsal view, showing structures and terms used in key.

There are about 380 species of cyclopoids parasitic on marine fishes. However, only 19 species belonging to six families are so far known to occur within the range covered by this manual (from Maine to Virginia). Since only a small fraction of fishes occurring off the coast of northeastern United States have ever been examined for the copepod parasites, certainly many more species of parasitic cyclopoids are yet to be discovered.

It is well known that a freshwater fish heavily infested with cyclopoids, particularly with those of the genera *Ergasilus* and *Lernaea*, often dies. Although no such reports have ever been made on marine fishes, a fish kill due to heavy infestation of marine cyclopoid copepods cannot be ruled out, because loss of weight and retardation of the rate of growth of the fish under the influence of parasitism is known.

In collecting specimens of parasitic cyclopoids, one must be very careful not to damage the attachment apparatus of the parasite, for, in many cases, this modified appendage carries important taxonomic information. Removal of the parasite from the host is preferably done under a dissecting microscope, but, if the removal must be done in the field, a generous amount of the host tissue must be taken together with the parasite. The parasite is subsequently removed from the collected host's tissue under a dissecting microscope in the laboratory. The collected specimens are preserved and stored in 70% alcohol. The study of their external anatomy always requires dissection of the appendages. This can be done first by soaking the specimen in lactic acid for several hours and then removing the appendages under a dissecting microscope with a pair of sharp needles. The appendages removed are studied under a compound microscope.

KEY TO THE MARINE CYCLOPOID COPEPODS PARASITIC ON FISHES OF THE NORTHEASTERN UNITED STATES

The following key is constructed for the female cyclopoids that have been reported parasitic on marine fishes from Maine to Virginia. A separate key to the male is not given because some of them are unknown and the others,

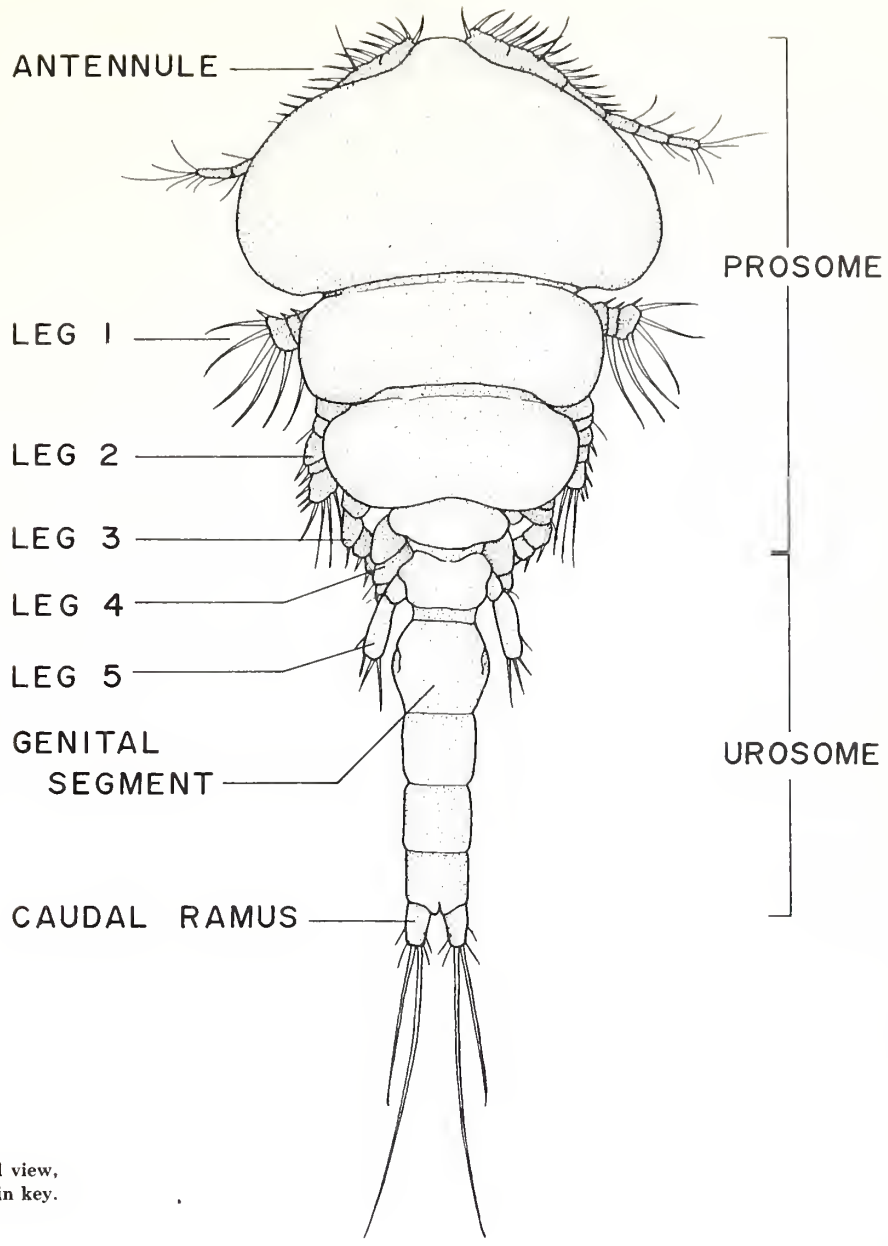


Figure 2.—*Holobomolochus albidus*; dorsal view, showing structures and terms used in key.

when they occur, are always in close association with their female partners.

Although 19 species of cyclopoids are known from the northeastern United States, the following key is prepared for identification of the 11 species of Chondracanthidae, one species of Philichthyidae, and one species of Tuccidae. Identification of the remaining three species of Bomolochidae, two species of Ergasilidae, and one species of Taeniacanthidae is not provided because these families are relatively large and very poorly known from the region. If a key to the few known species is provided, it might lead a user to misidentify an unreported species as one listed in the key.

1	Body typical copepod form (Fig. 2)	2
1	Body modified, not copepod form (Fig. 1)	4

2 (1) Antenna with single terminal claw (Fig. 3) . . . . . Ergasilidae

2 (1) Antenna bearing several terminal setae and claws (Fig. 4) 3

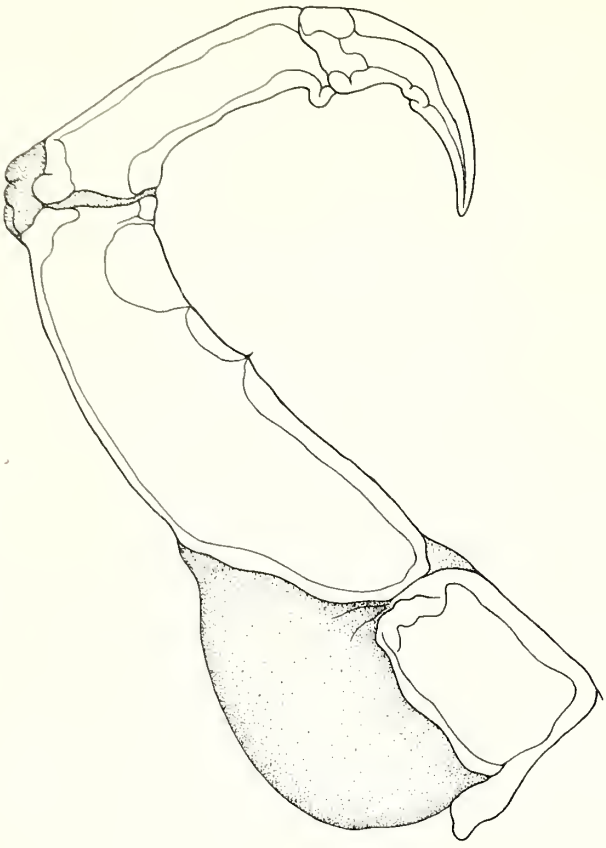
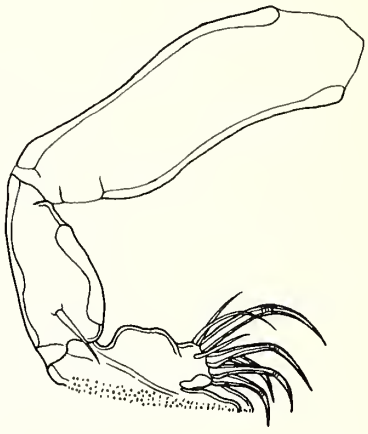


Figure 3.—*Ergacilus labracis*; antenna.

Figure 4.—*Tucca impressus*; antenna.



3 (2) Maxillary hook present (Fig. 5) . . . . . Taeniacanthidae

3 (2) Maxillary hook absent . . . . . Bomolochidae

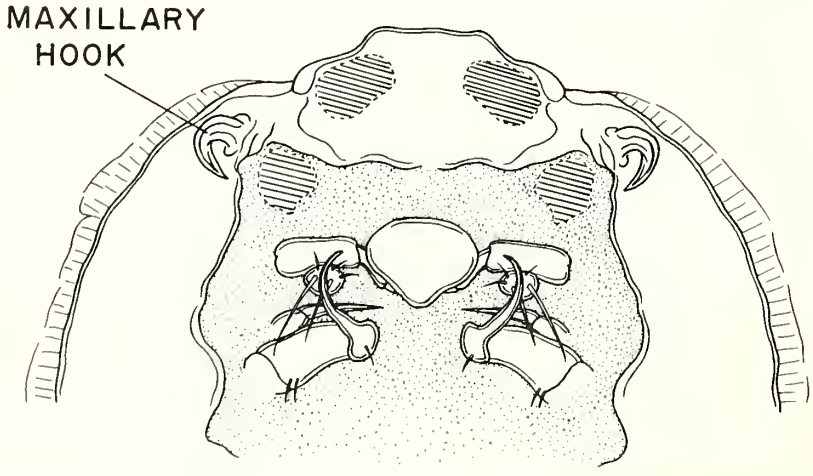


Figure 5.—*Anchistrotos occidentalis*; cephalothorax in ventral view with antennules and antennae removed.

4 (*1*) Without attachment apparatus, living loosely in cephalic canal of fish (fig. 6) . . . . . *Philichthys xiphiae*

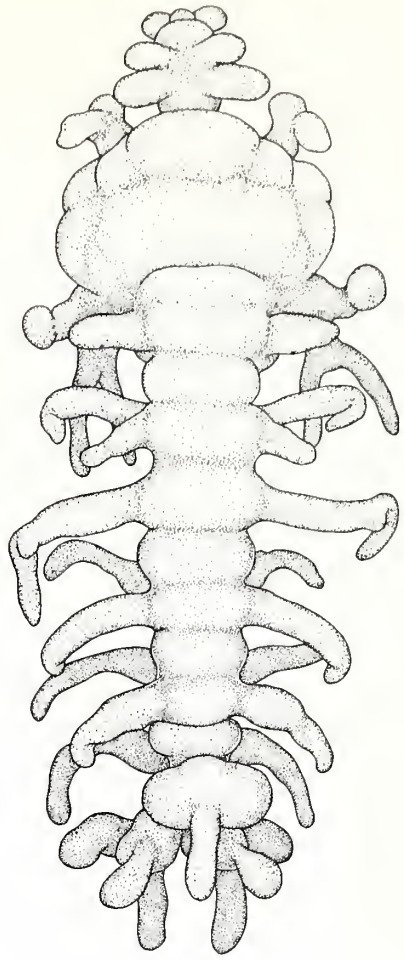


Figure 6.—*Philichthys xiphiae*; female.

4 (*1*) With attachment apparatus of modified antennae or maxillipeds, firmly attached to host tissue 5

5 (*7*) Antenna bearing several terminal setae and claws (Fig. 4) . . . . . *Tucca impressus*

5 (*7*) Antenna transformed into a tripartite process (Fig. 7) or a recurved hook (Fig. 8) 6

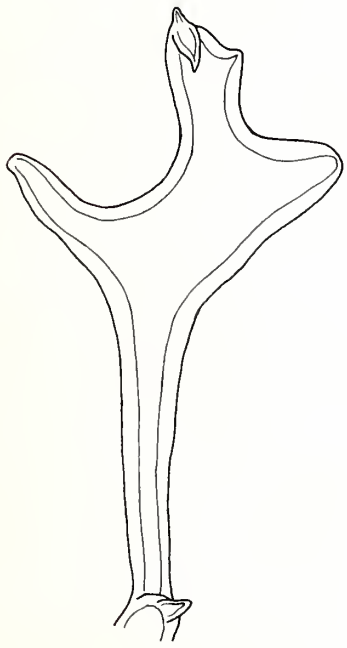


Figure 7.—*Blias prionotus*; antenna.

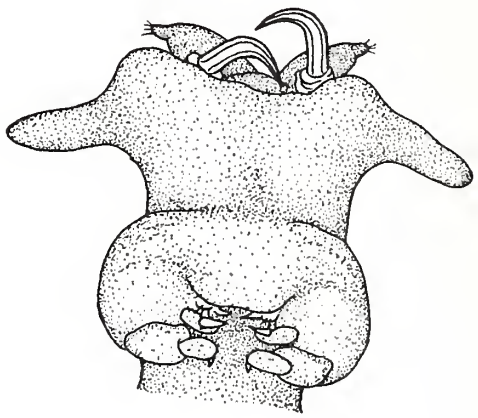


Figure 8.—*Pseudochondracanthus diceraus*; head, ventral view.

6 (5) Trunk region without any form of outgrowths; antenna tripartite (Fig. 7) . . . . . *Blias prionoti*

6 (5) Trunk region with outgrowths in form of processes, protrusions, or knobs; antennae uncinate (Fig. 8) 7

7 (6) Trunk region with only one pair of processes at the posterior end of the body (Fig. 1) 8

7 (6) Trunk region with more than one pair of processes 13

8 (7) One pair of lobate legs present; head bearing a pair of lateral processes (Fig. 8) . . . . . *Pseudochondracanthus diceraus*

8 (7) Two pairs of lobate legs present; head without lateral processes 9

9 (8) Legs unilobate (Fig. 9); parasite of elasmobranchs . . . . . *Acanthochondrites annulatus*

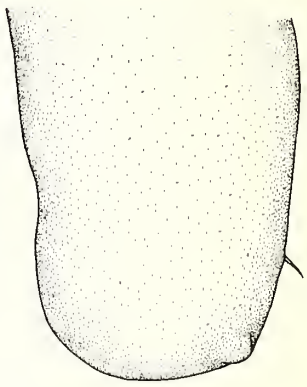


Figure 9.—*Acanthochondrites annulatus*; leg.

9 (8) Legs bilobate (Fig. 10); parasite of teleosts 10

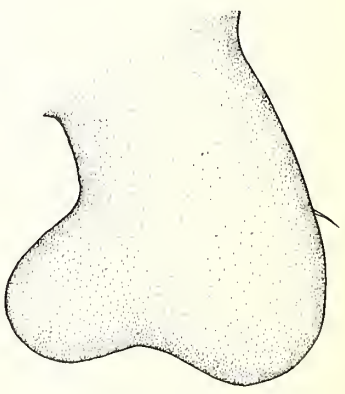


Figure 10.—*Acanthochondria phycidis*; leg.

10 (*9*) Rami of legs short and broad (Fig. 10) . . . . . .*Acanthochondria phycidis*

10 (*9*) Rami of legs long and conical (Fig. 11) 11

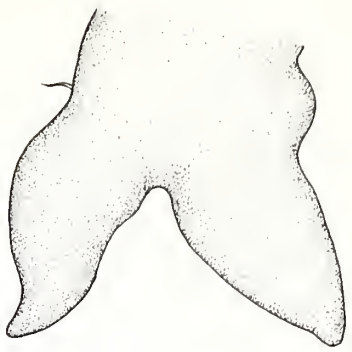


Figure 11.—*Acanthochondria galerita*; leg.

11 (*10*) Antennule small (relative to head) and filiform (Fig. 12) . . . . . *Acanthochondria exilipes*

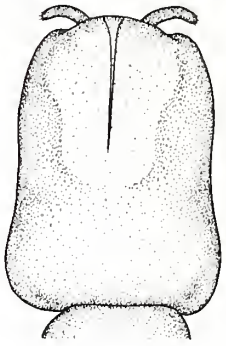


Figure 12.—*Acanthochondria exilipes*; head.

11 (*10*) Antennule large (relative to head) and lobate (Fig. 1) 12

12 (*11*) Rami of legs pointed (Fig. 11) . . . . . *Acanthochondria galerita*

12 (*11*) Rami of legs not pointed (Fig. 13) . . . . . .
. . . . . *Acanthochondria cornuta*

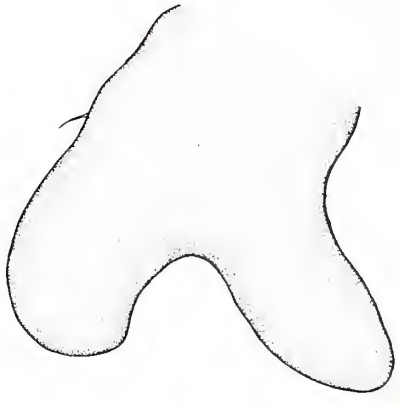


Figure 13.—*Acanthochondria cornuta*; leg.

13 (7) Legs partially modified, with saclike protopod and rodlike rami (Fig. 14) . . . . . *Chondracanthodes deflexus*

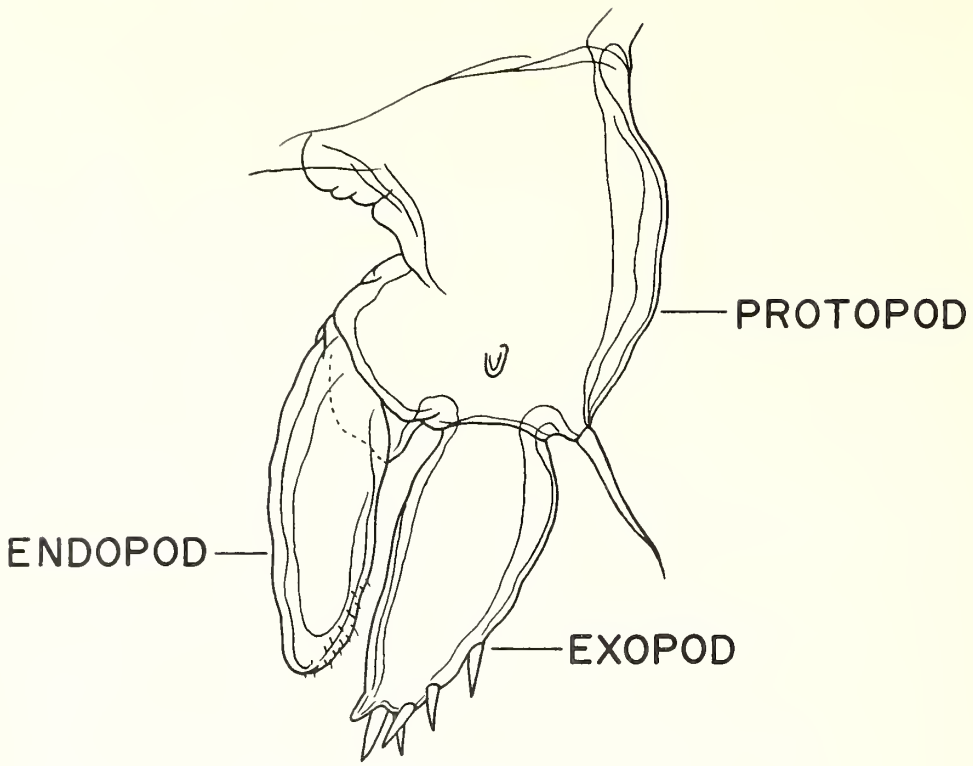


Figure 14.—*Chondracanthodes deflexus*; leg.

13 (7) Legs completely modified, either bilobate (Fig. 13) or trilobate (Fig. 15) 14

Figure 15.—*Chondracanthus nodosus*; leg.

14 (13) Legs trilobate (Fig. 15) . . . . . *Chondracanthus nodosus*

14 (13) Legs bilobate (Fig. 13) 15

15 (*14*) Head with a pair of cephalic horns; antennule small (relative to head) (Fig. 16) . . *Chondracanthus merluccii*

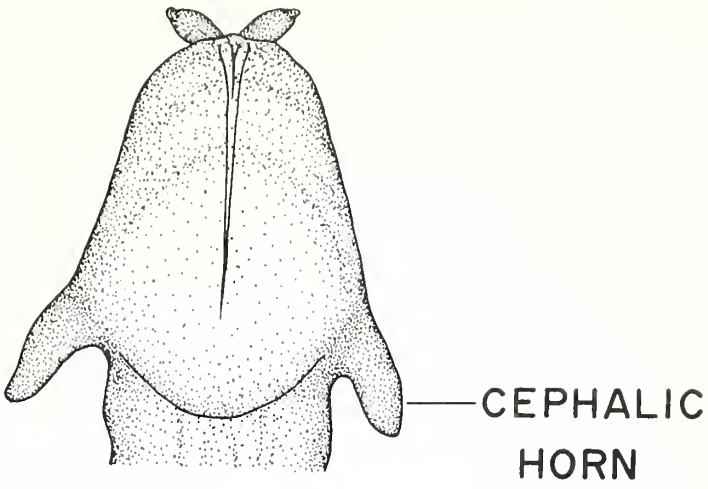


Figure 16.—*Chondracanthus merluccii*; head.

15 (*14*) Head without cephalic horns; antennule large (relative to head) (Fig. 17) . . . . . *Chondracanthus cottunculi*

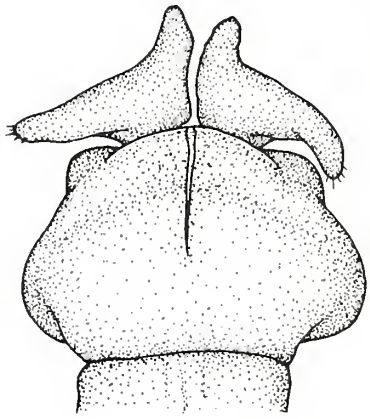


Figure 17.—*Chondracanthus cottunculi*; head.

ANNOTATED SYSTEMATIC LIST

This list is arranged alphabetically in families, genera under their family, and species under their genus. Notes on host and distribution are given. When more than one host is known, their names are arranged alphabetically in genera and species under their genus. If the common name of the host is known, it is given immediately preceding its scientific name. Reference to important works are cited at the end of each species.

Family BOMOLOCHIDAE

Holobomolochus albidus (Wilson 1932). In gill cavity of angler, *Lophius piscatorius*, off Woods Hole, Mass. (Vervoort 1969).

Nothobomolochus teres (Wilson 1911). In gill cavity of Gulf menhaden, *Brevoortia patronus*, off Texas; Atlantic menhaden, *B. tyrannus*, from Massachusetts to Florida; striped mullet, *Mugil cephalus*, off Texas (Pillai 1965).

Nothobomolochus saetiger (Wilson 1911). In gill cavity of tropical two wing flyingfish, *Exocoetus volitans*, off Woods Hole, Mass.; *Cypselurus callopterus* from Galápagos Islands (Wilson 1911).

Family CHONDRACANTHIDAE

Acanthochondria cornuta (Müller 1776). In gill and oral cavities of largescaled tonguesole, *Cynoglossus macrolepidotus*, off Ceylon; witch flounder, *Glyptocephalus cynoglossus*, in Massachusetts Bay and eastern North Atlantic; American plaice, *Hippoglossoides platesoides*, in North Sea, off Iceland and Greenland, and from Maine to Massachusetts; Atlantic halibut, *Hippoglossus hippoglossus*, off Midleton Island, Alaska; whiff, *Lepidorhumbus whiffiagonis*, in eastern North Atlantic; dab, *Limanda limanda*, in

Irish Sea and off Iceland; flounder, *Platichthys flesus*, in North Sea; European plaice, *Pleuronectes platessa*, in eastern North Atlantic; Alaska, plaice, *P. quadrituberculatus* off Pallas, Alaska; turbot, *Psetta maxima*, off Sweden; winter flounder, *Pseudopleuronectes americanus*, from Maine to Massachusetts (Ho 1970).

Acanthochondria exilipes Wilson 1932. On gills of tilefish, *Lopholatilus chameleonticeps*, off Martha's Vineyard, Nantucket, and Woods Hole, Mass. (Ho 1970).

Acanthochondria galerita (Rathbun 1886). In oral cavity of Gulf flounder, *Paralichthys albigutta*, off Florida· summer flounder, *P. dentatus*, off Woods Hole, Mass. (Ho 1971b).

Acanthochondria phycidis (Rathbun 1886). On gills of Chilean hake, *Merluccius gayi*, off Chile; spotted hake, *Urophycis reguis*, off Georgia and Florida; white hake, *U. tenuis*, off Martha's Vineyard, Mass.; unknown host from Falkland Islands (Ho 1971b).

Acanthochondrites annulatus (Olsson 1868). On gills of flapper skate, *Raja batis*, off Norway; spiny rasp skate, *R. kenojei*, in Sea of Japan; barndoor skate, *R. laevis* off South Harpswell, Maine (Ho 1970).

Blias prionoti Krøyer 1863. On gills of black drum, *Pogonias cromis*, off Mississippi; northern searobin, *Prionotus carolinus*, off North Carolina; soldier searobin, P. miles pectoralis, off Texas; leopard searobin, *P. scitulus*, off Florida; striped searobin, *P. evolans*, off Woods Hole, Mass.; bighead searobin, *P. tribulus*, off Florida (Ho 1970).

Chondracanthodes deflexus Wilson 1932. On gills of marlin-spike, *Nezumia bairdi*, off Woods Hole, Mass.; *Macrurus* sp. from Galápagos Islands; *Coryphaenoides abyssorum* off California (Ho 1970).

Chondracanthus cottunculi Rathbun 1886. In gill cavity of arctic sculpin, *Cottunculus microps*, and pallid sculpin, *C. thompsonii*, off New England coast (Ho 1971b).

Chondracanthus merluccii (Holten 1802). In oral and gill cavities of silver hake, *Merluccius bilinearis*, from Massachusetts to Florida; cape hake, *M. capensis*, off South Africa; European hake, *M. merluccius*, in eastern North Atlantic (Ho 1971b).

Chondracanthus nodosus (Müller 1776). In gill cavity of redfish, *Sebastes marinus*, in North Atlantic; deepwater rosefish, *S. mentella*, in eastern North Atlantic; Norway haddock, *S. viviparus*, in North Sea (Ho 1971b).

Pseudochondracanthus diceraus Wilson 1908. On gills of smooth puffer, *Lagocephalus laevigatus*, from Gulf of Mexico; northern puffer, *Sphoeroides maculatus*, from Massachusetts to North Carolina; southern puffer, *S. nephelus*, from Gulf of Mexico; bandtail puffer, *S. spengleri*, from North Carolina to Florida (Ho 1970).

Family ERGASILIDAE

Ergasilus labracis Krøyer 1863. On gill filament of striped bass, *Morone saxatilis*, from Massachusetts to Virginia (Roberts 1970).

Ergasilus manicatus Wilson 1911. On gill gilaments of sheepshead minnow, *Cyprinodon variegatus*, from Beaufort, N.C.; mummichog, *Fundulus heteroclitus*, from Cape Ann, Mass.; striped killifish, *F. majalis*, from Beaufort, N.C.; blackspotted stickleback, *Gasterosteus wheatlandi*, from Cape Ann, Mass.; rainwater killifish, *Lucania parva*, from Beaufort, N.C.; Atlantic silverside, *Menidia menidia*, from Woods Hole, Cape Ann, and Barnstable, Mass.; rainbow smelt, *Osmerus mordax*, from St. Andrews, New Brunswick (Roberts 1970).

Family PHILICHTHYIDAE

Philichthys xiphiae Steenstrup 1861. In cephalic canals of swordfish, *Xiphias gladius*, in Mediterranean, off European and American coasts off North Atlantic, New Zealand, and Japan (Delamare-Duboutteville 1962).

Family TAENIACANTHIDAE

Anchistrotos occidentalis Wilson 1924. On gills of striped burrfish, *Chilomycterus schoepfi*, from Woods Hole, Mass. (Humes and Rosenfield 1960).

Family TUCCIDAE

Tucca impressus Krøyer 1837. On fins of bridled burrfish, *Chilomycterus antennatus*, from Jamaica; striped burfish, *C. schoepfi*, from Massachusetts to Louisiana; porcupinefish, *Diodon hystrix*, from Jamaica; northern puffer, *Sphoeroides maculatus*, from Woods Hole, Mass.; spinyback puffer, *S. marmoratus*, from Jamaica (Ho 1967a).

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The Board, which established the format for the "Marine Flora and Fauna of the Northeastern United States," invites systematists to collaborate in the preparation of manuals, reviews manuscripts, and advises the Scientific Editor of the National Marine Fisheries Service.

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COORDINATING EDITOR'S COMMENTS

Publication of the "Marine Flora and Fauna of the Northeastern United States" is most timely in view of the growing universal emphasis on environmental work and the urgent need for more precise and complete identification of coastal organisms than has been available. It is mandatory, wherever possible, that organisms be identified accurately to species. Accurate scientific names unlock the great quantities of biological information stored in libraries, obviate duplication of research already done, and often make possible prediction of attributes of organisms that have been inadequately studied.

Ju-shey Ho began his study of the systematics of the parasitic Copepoda in 1960 when he was a teaching assistant at the Department of Zoology, National Taiwan University, Taipei, Taiwan. In 1962 he went to Boston University to pursue graduate studies on the copepod parasites of marine animals. Ho joined the faculty of California State University, Long Beach, in 1970 where he has continued his research on parasitic Copepoda. His studies have resulted in more than 50 papers on the systematics of marine parasitic copepods, including a monographic revision of Chondracanthidae at the generic level. Currently he is working on a series of copepod parasites from the fishes of the Great Barrier Reef, Australia.

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